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EVALUATION OF POPULATION-VARIETIES DEVELOPED WITHIN A WHEAT PARTICIPATORY BREEDING PROGRAM IN FRANCE: PERFORMANCES, DIVERSITY, STABILITY AND ADAPTATION

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Abstract: Modern agricultural systems rely on little crop genetic diversity, especially with the use of homogeneous varieties grown on large areas. However crop genetic diversity within fields is a lever for a more sustainable production, allowing for a greater stability through combined resistances to biotic and abiotic stress, and buffering environmental heterogeneity which characterizes organic systems. In France, a Participatory Plant Breeding (PPB) project has been applied on bread wheat since 2006 involving farmers and facilitators of the farmers' seed network Réseau Semences Paysannes and INRA researchers for the development of populations based on a decentralized selection in farmers' fields. This project leads to the development of heterogeneous populations whose intra-variety genetic diversity should allow them to adapt to farmers' practices and environments. We evaluated the agronomic behavior, genetic diversity, stability and local adaptation of ten populations developed within the PPB program compared to two commercial pure line varieties. Some populations had very interesting responses when considering grain yield, biomass production and protein content, and six of them were not significantly less productive than the two commercial varieties when comparing overall grain yield per population. While no clear evidence of local adaptation was detected, we found that populations' quality and in a lesser extent grain yield were more stable over years than that of commercial varieties. Protein content stability over time was positively correlated to genetic diversity with no significant drawback on protein production.

Introduction: Faced with the challenges posed by dominant agricultural systems, alternatives such as agroecology or organic agriculture have emerged, advocating spatial and temporal diversification to support a resilient agriculture based on natural regulations. One of the identified lever is to increase genetic diversity at the field level which allows for better disease regulation (Mundt 2002), greater resilience to climate variability (Østergård et al. 2009, Finckh et al. 2000), and

better ecosystems functioning (Cardinale et al. 2011, Cook-Patton et al. 2011). In France a Participatory Plant Breeding (PPB) project has been applied on bread wheat since 2006, involving farmers and facilitators of the farmers' seed network Réseau Semences Paysannes (RSP) and INRA researchers (Diversity, Evolution and Adaptation of Populations team). The project aims at developing farmers' varieties that are adapted to farmer's objectives and needs based on decentralized selection in farmers' fields (Rivière et al. 2013). Methods and tools for on-farm breeding were developed to help farmers' reappropriation of on-farm breeding knowledge and seed autonomy. This project leads to the development of heterogeneous populations-varieties whose within-variety genetic diversity is expected to provide the capacity to adapt to farmers' practices and environments, and to stabilize the production over time. An experiment was carried out to evaluate ten early populations developed by farmers within the PPB program (hereafter PPB populations) compared to two commercial lines, in terms of agronomic performances, genetic diversity, stability over time and local adaptation (Goldringer et al. 2020, van Frank et al. 2020).

Material and methods: We evaluated the varieties during two growing seasons on six farms presenting contrasted pedo-climatic conditions. In each farm, the trial consisted in a complete randomized two blocks design. Morphological and agronomic traits have been measured such as plant height, spike length and weight, spike color, curve and presence of awns on individual plants, and thousand kernel weight, protein content and yield at the plot level. We searched for local adaptation of the PPB populations, considering the farm where they have been selected as their home and testing local vs non local status. Stability over time was quantified by the coefficient of variation of each variety associated with the *Year* effect and *Year x Farm* interaction. Within-variety genetic diversity, quantified by the Nei index, was assessed using SNP markers on 90 individuals per population and 30 individuals per commercial line. These markers were located in neutral zones of the genome (52 markers) and on candidate genes for heading precocity (34 markers).

Results: For most measured traits, although the *Population* effect was limited except for spike color and presence of awns, the *Population x Farm* interaction was larger than the *Population x Year* interaction, highlighting the potential to select populations adapted to environments and practices. Some PPB populations had very interesting responses when considering grain yield, protein content as well as biomass production and weed competitiveness as they were taller than the commercial pure lines. Six of them were not significantly less productive than the two commercial pure lines when comparing overall grain yield per population. These varieties were interesting especially in less productive environments were they yielded more than commercial lines. While significant *Population x Farm* interactions were found for yield and yield components, no clear pattern of local adaptation was detected. However, we found that populations' protein content was more stable over years than that of commercial pure lines, as the mean coefficient of variation associated to *Year* effect and *Year x Farm* interaction were 23.8% and 35.3% respectively ($p=0.03$). Moreover, protein content stability over time was positively correlated to within-variety genetic diversity ($R=0.58$, $p=0.047$), with no significant drawback on protein production ($R=0.38$, $p=0.22$). Regarding grain yield, commercial varieties were more unstable across farms. Intravarietal genetic diversity reflected the history of the varieties and farmers practices as the most diversified mixtures in terms of number and type of components were also showing larger genetic diversity.

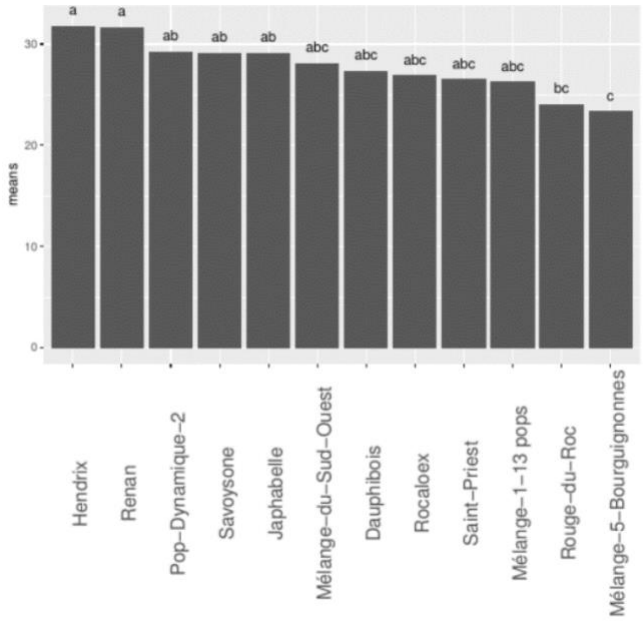

Figure 1: Mean grain yield of the two commercial lines (Renan and Hendrix) and the ten PPB populations, over the 6 farms and 2 years

Discussion: These results seemed promising to the farmers involved in the PPB process, as they exhibit interesting yield and protein content compared to commercial varieties – one of which, Renan, is widely used in organic farming. The good performance of some of these wheat PPB varieties observed on farms with more limiting conditions may be related to the efficiency of the participatory approach to identify and select for plants and varieties adapted to these more irregular and difficult conditions. These results also show the wide adaptive potential of PPB populations, stressing the importance of seed exchange networks for agrobiodiversity conservation and use. They emphasized the benefits of genetic diversity for stability over years which is of great interest to farmers.

Disclosure of Interest: None Declared

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